CCAMLR

Commission for the Conservation of Antarctic Marine Living Resources
Commission pour la conservation de la faune et la flore marines de l'Antarctique
Комиссия по сохранению морских живых ресурсов Антарктики
Comisión para la Conservación de los Recursos Vivos Marinos Antárticos

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WG-SAM

Continuation of multi-Member research on the Dissostichus spp. exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) by Australia (notification ID 98422, 98423), France (94903, 94904), Japan (94886, 94887), Republic of Korea (94889, 94890) and Spain (94835)

Delegations of Australia, France, Japan, Republic of Korea and Spain

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Abstract

Exploratory fishing for toothfish (*Dissostichus* spp.) in East Antarctica (Divisions 58.4.1 and 58.4.2) began in 2003. Robust stock assessments and catch limits according to CCAMLR decision rules remain to be determined for these Divisions. WG-FSA-16/29 outlines the first multi-member toothfish exploratory fishery research plan for East Antarctica, including research objectives, methods and milestones in accordance with ANNEX 24-01/A. In 2016, the Scientific Committee agreed that the research plan was appropriate to achieve its objectives (SC-CAMLR-XXXV, para. 3.244). We present here a proposal for the continuation of the research plan as set out in WG-FSA-16/29. All significant changes to the plan are outlined in Section A. A summary of data collection in 2016/17 (Section B), and issues arising from the 2016/17 season (Section C) are also provided.

A) Summary of changes

Proposed initial allocation of revised 2017/18 catch limits

We propose to adopt a similar approach for the initial research catch allocation among participating Members to that adopted by the Commission in 2015 and 2016 (details in Section 4a). Table 1 provides the initial proposed percentages of the 2017/18 catch limits to be allocated to each Member in each research block (Table 1). The final percentages for the 2017/18 season are yet to be determined. Once finalised, the catch percentages will be applied to the total catch limits recommended by the Scientific Committee in 2017, to determine the catch allocations in tonnages for each participating Member.

Additional vessel

This proposal includes two Australian-flagged vessels for Division 58.4.1 (as opposed to one vessel in 2016/17): *Antarctic Chieftain* and *Antarctic Discovery* (details in Table 7 and Section 5d). Of the two Australian-flagged vessels, only the *Antarctic Chieftain* intends to conduct research in Division 58.4.2.

Estimation of local biomass

Milestone 1.7 was for the estimation of local biomass within research blocks by Petersen tag-recapture models, and was scheduled for submission to WG-FSA-17. This milestone has been removed because this work is now undertaken by the Secretariat.

Research block 5841_6

In 2016, the Scientific Committee endorsed the recommendation from WG-FSA-16 that the proposed new research block 5841_6 be opened on an interim basis, with results to be reviewed by WG-SAM and WG-FSA in 2017 (SC-CAMLR-XXXV, para. 3.245). A summary of data collection undertaken in research block 5841_6 during the 2016/17 season is provided in Section B.

Table 1. Proposed percentages for initial catch allocations for the 2017/18 season for research plans in Divisions 58.4.1 and 58.4.2 by Research Block and Member. For example, in this case 50% of the catch limit in research block 5841_2 would be allocated to Australia, and the other 50% to Spain.

ASD	SSRU	Research Block	Catch allocation (% of total catch limit)					
			AUS	ESP	FRA	JPN	KOR	Total
58.4.1	C	5841_1			33.3	33.3	33.3	100
		5841_2	50[a]	50[a]				100
	E	5841_3	13	13	26	32	16	100
		5841_4			100			100
	G	5841_5					100	100
		5841_6	50[a]	50[a]				100
58.4.2	E	5842_1	100					100

[a] Allocation for research grid, and additional fishing within the research block if any catch is still available.

B) Data collection during the 2016/17 season

This section provides a brief summary of the volume of data collected during the 2016/17 season. More detailed results will be submitted to WG-FSA-17 in accordance with the research milestones in Section 1b.

Table 2. Catch and data collected by Australia, Spain, France and Republic of Korea in Divisions 58.4.1 and 58.4.2 during the 2016/17 season.

	AUS	ESP	FRA	KOR
Hauls	29	74	14	146
SSRU	58.4.1G	58.4.1C 58.4.1E 58.4.1G	58.4.2E	58.4.1C 58.4.1E 58.4.1G 58.4.2E
TOA (tonnes)	9.2	64.1	14.6	153.1
GRV (tones)	10.6	5.9	1.2	9.3
Biological data (num. fish)	338	1630	351	2165
TOA otoliths collected	210	393	145	1339
TOA tagged	51	329	76	805
TOA recaptures	1	6	0	7
BVC deployments	12	-	-	-
CTD deployments	17	-	-	33

Research block 5841_6

Both Australia and Spain conducted research in research block 5841_6 in the 2016/17 season, deploying a total of 80 longlines. A total of 53.3 tonnes of *Dissostichus mawsoni* was captured in this research block, 280 *D. mawsoni* were tagged and released, and there were 5 tag recaptures.

C) Issues arising from the 2016/17 season

Macrourid bycatch in Division 58.4.1

The catch limit for Macrourids for the 2016/17 in research block 5841_6 (SSRU 58.4.1G) of 14 tonnes (CCAMLR-XXXV, Table 1) was reached on 27 January 2017 when the research block was closed with 39 percent of the total catch limit (90 tonnes) for TOA remaining. We will present further analyses on this bycatch issue at WG-FSA-17, with a view towards reducing fishing impacts on Macrourids and also allowing for the fulfillment of proposed research objectives.

Details of research in accordance with ANNEX 24-01/A, Format 2

1. Main objective

(a) Objectives for the research and why it is a priority for CCAMLR

Objective 1: Collect data required for an assessment of the status and productivity of toothfish stocks in Divisions 58.4.1 and 58.4.2. Standard catch, fishing effort, tagging and biological data will be collected under Conservation Measures 41–05 and 41–11.

Objective 2: Collect and utilise environmental data to inform spatial management approaches for the conservation of toothfish, bycatch species and representative areas of benthic biodiversity.

Objective 3: Collect data on the spatial and depth distributions of bycatch species, and inform bycatch mitigation measures.

Objective 4: Improve understanding of trophic relationships and ecosystem function to assist the development of ecosystem-based fisheries management approaches.

(b) Detailed description of how the proposed research will meet the objectives, including annual research goals

Objective 1:
Annual milestones (Table 3) include the evaluation and reporting on the ageing program, and the evaluation and reporting on estimation of toothfish maturity parameters. Investigation of stock structure using genetic approaches will be coordinated and reported on annually by Spain.

Data will be updated following the 2016/17 season and used for estimation of toothfish life-history parameters. Data on toothfish distribution, biology, demography and movements will be used to refine and test hypotheses on toothfish stock structure across East Antarctica, and links with other areas.

It is expected that the data collected up to and including the 2017/18 season will allow for an initial assessment of toothfish stocks within individual research blocks, as well as the development of approaches to scale-up these estimates across entire SSRUs and Divisions. In addition, data on stock structure and relationships between toothfish catches and environmental variables (from Objective 2) can be used to make predictions about spatial variations in toothfish relative density. With this information, 2018 will see an evaluation of existing management arrangements in Divisions 58.4.1 and 58.4.2, and updated advice on precautionary catch limits as appropriate.

Table 3. Scheme of milestones under Objective 1.

Date	Milestone	Research coordination
WG-FSA-16	1.1 Preliminary summary of sample sizes, catch composition and tagging activities	Australia
	1.2 Preliminary report on ageing of collected toothfish otoliths	Spain
WG-FSA-17	1.3 Ageing of collected toothfish otoliths & estimation of growth parameters	Spain
	1.4 Estimation of toothfish maturity parameters	Republic of Korea
	1.5 Develop a hypothesis for toothfish stock structure across East Antarctica, and links with other areas using data on toothfish biomass, distribution, biology, demography and movement	Australia
	1.6 Genetic analyses for further refinement of the stock structure hypothesis	Spain
	1.7 Estimate local biomass within research blocks	Secretariat
WG-FSA-18	1.8 Ageing of collected toothfish otoliths & updated estimation of growth parameters	Spain
	1.9 Updated estimation of toothfish maturity parameters	Republic of Korea
	1.10 Initial integrated stock assessment models for toothfish within research blocks or across SSRUs and Divisions	Australia, France, Japan and Spain

Objective 2: Environmental data collection will entail the attachment of conductivity, temperature and depth loggers (CTD loggers) and Benthic Video Cameras (BVCs) to fishing gear. BVCs will be deployed from vessels flagged to Australia and Spain, and CTD loggers will be deployed from vessels flagged to Australia and Republic of Korea (see Section 2b, 3a).

BVCs and CTD loggers will record, or be used to infer:

- Water temperature
- Salinity
- Depth of longline deployments
- Substrate composition
- Density and species composition of benthic invertebrates
- Three-dimensional structure of benthic communities

These data will be used in spatially-explicit habitat-use models for toothfish (e.g. Mormede et al. 2014; Welsford 2011; Robinson & Reid 2014). Environmental and bathymetric data will contribute to models of toothfish habitat use, and the refinement of toothfish stock hypotheses, following surveys in 2016/17 and 2017/18.

Vertical depth, temperature and salinity profiles will be shared with the Southern Ocean Observing System (SOOS), delivering additional value from the proposed research. Data on benthic communities will also provide critical information on the distribution of Vulnerable Marine Ecosystems (VME) within the study regions.

Table 4. Scheme of milestones under Objective 2

Date	Milestone	Research coordination
WG-FSA-17	2.1 Develop spatially-explicit habitat-use models for toothfish using data from CTDs and BVCs	Australia
WG-FSA-18	2.2 Update spatially-explicit habitat-use models for toothfish using data from CTDs and BVCs	Australia
	2.3 Sharing of environmental data with SOOS	Australia

Objective 3: Comprehensive bycatch data will be collected in accordance with relevant conservation measures (33-01, 41-05 and 41-11). These data will help to inform estimations of the distribution, relative abundance, and life history of the main bycatch species. It is expected that data collected up to 2017/18 will allow for assessment of spatial and depth distributions and comparison of relative densities between areas for predominant bycatch species.

Table 5. Scheme of milestones under Objective 3

Date	Milestone	Research coordination
WG-FSA-18	3.1 Estimation of spatial distribution, relative abundance, and life history of main bycatch species	Australia and France

Objective 4: Samples of fish muscle tissue (Republic of Korea and Spain), stomach contents and plankton and zooplankton (Republic of Korea) will be collected for investigation of trophic relationships and ecosystem function using stable isotope analyses. Trophic and ecosystem studies will be evaluated and reported on annually by Republic of Korea.

Table 6. Scheme of milestones under Objective 4

Date	Milestone	Research coordination
WG-FSA-16	4.1 Estimates of trophic relationships and ecosystem function using stable isotope analyses	Republic of Korea
WG-FSA-17	4.2 Estimates of trophic relationships and ecosystem function using stable isotope analyses	Republic of Korea
WG-FSA-18	4.3 Estimates of trophic relationships and ecosystem function using stable isotope analyses	Republic of Korea

(c) Rationale for research, including relevant existing information on the target species from this region, and information from other fisheries in the region or similar fisheries elsewhere

Toothfish utilise a broad range of habitats throughout their lifespan, from the epipelagic as planktonic larvae, to benthopelagic slope habitats in excess of 2000 m in depth (Hanchet et al. 2010). Previous studies have revealed varied movement patterns among individuals but also a relatively predictable distribution of these fish along the Antarctic continental shelf (Welsford 2011). Results of genetic studies have been consistent with the existence of limited gene flow among *D. mawsoni* populations across regions (East Antarctica, Ross Sea and the South Shetland Islands; Kuhn and Gaffney 2008, Mugue et al. 2013). However, additional sampling is required to determine whether this species exhibits discrete stock structure or a pattern of isolation by distance across its global distribution (Kuhn and Gaffney 2008).

There have been no integrated toothfish stock assessments in Divisions 58.4.1 and 58.4.2. Here, biomass estimation (e.g. through tag-based methods) and a better understanding of stock structure are research priorities. The predominance of large mature fish and absence of juveniles on nearby BANZARE Bank (Division 58.4.3b) suggest that it may be an important spawning ground for *D. mawsoni* (Welsford et al. 2008; Taki et al. 2011; Figure 1). In contrast, based on catches across Divisions 58.4.1 and 58.4.2 between years 2003–2011, the region around Prydz Bay (SSRU 58.4.2E) had the highest predicted catch rate of juvenile *D. mawsoni* (Welsford 2011). Therefore, it is hypothesised that mature fish on BANZARE Bank originate from nearby locations in East Antarctica, especially Prydz Bay (Welsford et al. 2008), which may serve as nursery areas (Welsford 2011). This stock hypothesis includes similar latitudinal patterns in sexual maturity and size composition to those hypothesised for the Ross Sea (Hanchet et al., 2008; Welsford et al. 2008). Combined, these stock models suggest a single stock across Division 58.4.1, 58.4.3b and Prydz Bay in 58.4.2. Further data on the distribution of different size-classes and maturity stages of toothfish will help refine these models of stock structure for use in assessments.

2. Fishery operations

(a) Fishing Members

Australia, France, Japan, Republic of Korea and Spain

(b) Vessels to be used

Table 7. Fishing vessels of Australia

Vessel name Information	*Antarctic Chieftain* www.ccamlr.org/en/node/83684
Vessel owner	Australian Longline Pty Ltd
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Fremantle, Registration 859032
Radio call sign	VJT6415
Overall length and tonnage	62.8 m, 1148 MT
Equipment for determining position	GPS and other vessel monitoring systems required under CM10-04
Fishing processing/storage capacity	15 tonnes per day headed & gutted, blast frozen. Carrying capacity 480t. Capacity of all fish holds 1,090m^3
Divisions	58.4.1 and 58.4.2
Vessel name Information	*Antarctic Discovery* https://www.ccamlr.org/en/node/90595
Vessel owner	Australian Longline Pty Ltd
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Hobart, Registration 861507
Radio call sign	VKAD
Overall length and tonnage	55.3 m, 1580 MT
Equipment for determining position	GPS and other vessel monitoring systems required under CM10-04
Fishing processing/storage capacity	15 tonnes per day headed & gutted, blast frozen. Carrying capacity 410t. Capacity of all fish holds 851m^3
Divisions	58.4.1

Table 8. Fishing vessel of France

Vessel name Information	*Le Saint-André* www.ccamlr.org/en/node/75730
Vessel owner	SNC Saint-André
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Port aux Français FK 928451
Radio call sign	FNTD
Overall length and tonnage	56.4 m, 416 tonnes
Equipment for determining position	Balise Irridium type Thorium
Fishing processing/storage capacity	Fish processing capacity: ≤ 10 tons per day Freezer hold capacity: 300 tons.
Divisions	58.4.1

Table 9. Fishing vessel of Japan

Vessel name Information	*Shinsei maru No.3* www.ccamlr.org/en/node/75733
Vessel owner	TAIYO A & F CO., LTD.
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Yaizu-Japan / 128862
Radio call sign	JAAL
Overall length and tonnage	47.2 m, 735 t
Equipment for determining position	GPS FURUNO GP500MK2
Fishing processing/storage capacity	Fish processing capacity: 10 tonnes per day Freezer hold capacity: 502.4 m^3
Divisions	58.4.1

Table 10. Fishing vessel of Republic of Korea

Vessel name	*Southern Ocean*
Information	To be updated prior to WG-SAM-17 (new entry)
Vessel owner	Hongjin Corporation
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	To be updated
Radio call sign	To be updated
Overall length and tonnage	To be updated
Equipment for determining position	To be updated
Fishing processing/storage capacity	To be updated
Divisions	58.4.1

Table 11. Fishing vessel of Spain

Vessel name	*Tronio*
Information	www.ccamlr.org/en/node/75760
Vessel owner	Pesquerías Georgia S.L.
Vessel type	Commercial bottom longline fishing vessel
Registration port/number	Cillero/ 3GC-1-2-05
Radio call sign	ECJF
Overall length and tonnage	55 m, 1058 tonnes (GRT)
Equipment for determining position	VMS-c
Fishing processing/storage capacity	42.7t / 635.3 m^3
Divisions	58.4.1

(c) Target species

Dissostichus mawsoni and *Dissostichus eleginoides.* Antarctic toothfish (*Dissostichus mawsoni*) will be the primary species caught, and the focus for Objectives 1, 2 and 4.

(d) Fishing or acoustic gear to be used

- ***Longline type***
  This research will employ a combination of Mustad Autoline system with integrated weight-longline (Australia and France), Spanish longline (Spain) and trotline (Japan and Republic of Korea). Full descriptions of gear configurations and deployment are located in the CCAMLR Fishing Gear Library at http://www.ccamlr.org/en/publications/fishing-gear-library.

- ***Other sampling gear***
  - Echosounders (e.g. Simrad ES60; ES 70, 38 kHz; JRC JFV-250).

- Conductivity, temperature and depth (CTD) loggers
- Benthic video cameras
- Archival tags (MiniPAT; Wildlife computers)

- ***Type of acoustic gear and frequency***
  If possible, vessels will collect acoustic 18, 38 and 120 kHz data as part of a program by the Integrated Marine Observing System (IMOS) for risk-based analyses of potential impacts on non-target fish populations or ecosystem interactions arising from impacts on the target stock.

(e) Fishing regions (divisions, subareas and SSRUs) and geographical boundaries

This research plan includes all existing research blocks in Division 58.4.1, and research block 5842_1 in Division 58.4.2. The geographical boundaries of research blocks are listed in Conservation Measures 41-11 and 41-05. We also propose to maintain the existing research grids (Appendix 1, 2) for ongoing stratified surveys by Australia and Spain in SSRUs 58.4.1C and 58.4.1G.

<u>Fishing regions in Division 58.4.1</u>
- Research blocks (Figure 1)
  - 5841_1 (SSRU 58.4.1C)
  - 5841_2 (SSRU 58.4.1C; encompasses research grid, Appendix 1)
  - 5841_3 (SSRU 58.4.1E)
  - 5841_4 (SSRU 58.4.1E)
  - 5841_5 (SSRU 58.4.1G)
  - 5841_6 (SSRU 58.4.1G; encompasses research grid, Appendix 2)

<u>Fishing region in Division 58.4.2</u>
- Research block (Figure 1)
  - 5842_1 (SSRU 58.4.2E)

(f) Estimated dates of entering and leaving the CCAMLR Area

Table 12. Estimated months of operation (shaded green) in the CCAMLR Area for each notifying Member. Cut-off dates for confirmation of intention to fish, and commencement of fishing are outlined in Section 4a.

Notifying Member	2017	2018											
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Australia													
France													
Japan													
Rep. of Korea													
Spain													

3. Survey design, data collection and analysis

(a) Research survey/fishing design (description and rationale)

- ***Spatial arrangements or maps of stations/hauls (e.g. randomised or gridded)***
  To expedite estimations of toothfish distribution and biomass in Division 58.4.1, depth-stratified fishing effort will be concentrated in research blocks 5841_1, 5841_2, 5841_3, 5841_4, 5841_5 and 5841_6 (Figure 1). Similarly, fishing in SSRU 58.4.2E will take place within research block 5842_1. These locations are expected to contain the highest concentration of tagged fish, and fishing is less likely to be restricted by sea-ice (Figure 3).

  Depth-stratified fishing by Australia and Spain within SSRUs 58.4.1C and 58.4.1G will also occur within research grids comprised of twenty-five 10 x 5 km cells, which are centred on the locations of previous depletion experiments undertaken by the Spanish vessel *Tronio* (Sarralde et al. 2014; Figure 1). Structured fishing around these locations and within research blocks will allow for development of models to examine the mechanisms behind previously-identified areas of relative high fish density (Sarralde et al. 2014), and comparison of toothfish size/age structure along the shelf of East Antarctica. These comparisons will be used to refine the current stock hypothesis for the region (Section 1c; Figure 1), especially in relation to the importance of Prydz Bay as a nursery area, and identifying aggregations of mature fish other than BANZARE Bank. Fishing in different locations will be stratified across similar depths (see below). The catch composition of bycatch species across depth strata can also be used to inform the design of spatial bycatch mitigation measures.

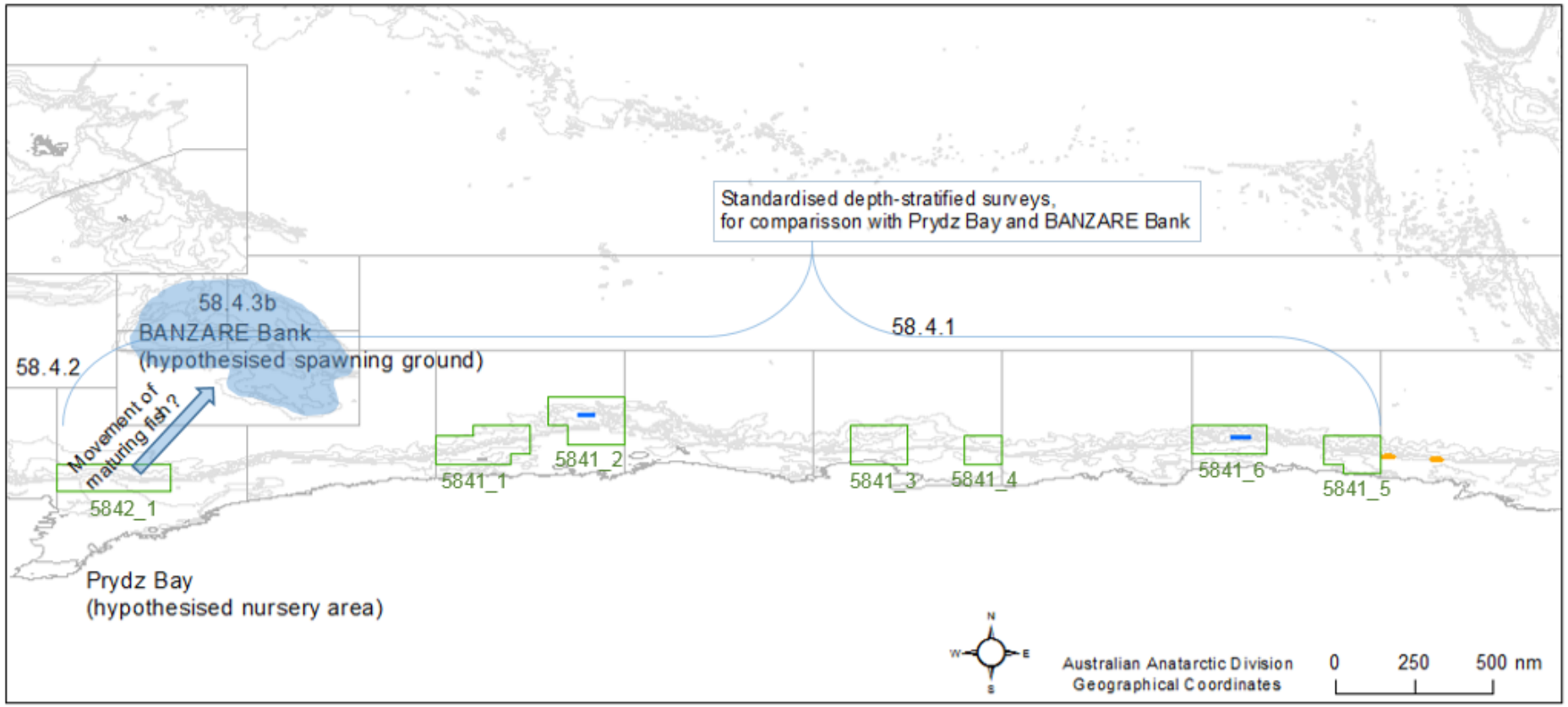

Figure 1. Depth-stratified fishing will occur in research blocks 5842_1 and 5841_1 – 5841_6 (green boxes/labels), and will contribute to refinement of the stock hypothesis for *Dissostichus mawsoni* across the region (shown in blue). Surveys in comparable depths and habitats across a broad geographic scale will provide information on the location and relative importance of potential nursery and spawning areas. Research grids containing twenty-five 10 x 5 km cells (blue boxes) are centered on previous depletion-experiment locations in SSRUs 58.4.1C and 58.4.1G. Grey boxes = SSRU boundaries, orange = known VME.

- ***Stratification according to e.g. depth or fish density***

  Fishing will be distributed across a range of depth strata where possible (<1000, 1001–1500, 1501–2000 m). Each Member will deploy at least 5 longlines in each depth strata (where present and sea-ice permitting) in each research block surveyed. Spatially-stratified fishing by Australia and Spain inside stratification grids will include ≥1 longline deployments per Member in each grid cell (Appendix 1, 2), catch limit and sea-ice permitting. The completion of sampling within stratification grids will take priority over sampling more broadly within the same research block. Once these minimum requirements for sampling in depth strata and stratification grids are fulfilled, vessels may conduct additional fishing within the research blocks and stratification grids, catch limit permitting. Hence it is anticipated that a combination of stratified and exploratory fishing may occur within each research block.

- ***Calibration/standardisation of sampling gear***

  A full description of gear configuration (see Section 2d) and deployment is located in the CCAMLR Fishing Gear Library at *http://www.ccamlr.org/en/publications/fishing-gear-library*. Additional information about longline deployments, such as minimum separation distance and soak time, can be found in the Data Collection Plan for Exploratory Fisheries (Conservation Measure 41-01 Annex 41-01/A). Details on the fishing gears and deployment methods, as well as variables that can be difficult to control (e.g. soak time and percentage of hooks baited), will be recorded so they may be standardised *a posteriori*.

- ***Proposed number and duration of stations/hauls***

  In SSRUs containing stratification grids (i.e. 58.4.1C and 58.4.1G), fishing will include ≥ 2 longline deployments in each grid cell (i.e. 1 each by Australia and Spain), catch limit and sea-ice permitting. Fishing within research blocks in other SSRUs will include at least 5 longlines in each depth strata, where present, and catch limit and sea-ice permitting (i.e. <1000, 1001–1500, 1501–2000 m). Once these minimum requirements have been met, the vessels will assess sea ice conditions and bycatch rates and continue sampling more broadly within the same research block. Minimum soak time of each set will be 6 hours.

- ***Tagging rates and other performance metrics such as tag overlap statistics for tagging programs***

  A key element of this multi-member research plan is a well-coordinated multi-year tagging program involving repeatedly visiting relatively small areas, and a commitment from all vessels to high tagging performance and to optimising the health of tagged fish.

  The research will target toothfish of all sizes in order to meet CCAMLR tagging requirements outlined in Conservation Measure 41-01 Annex C. Only fish in suitable condition according to the CCAMLR Tagging Protocol (*https://www.ccamlr.org/en/science/ccamlr-tagging-program*) will be tagged and released. Five fish per retained tonne (green weight) will be tagged with two external T-bar tags inserted into the dorsal musculature. Size overlap will be maintained at > 60%, with an aim to achieve > 80% tag size overlap.

- ***Other requirements***

  CTD loggers will be attached from *Antarctic Chieftain* (AUS), *Antarctic Discovery* (AUS) and *Southern Ocean* (KOR; Table 13). Benthic video cameras (BVCs) will be attached

from *Antarctic Chieftain* (AUS), *Antarctic Discovery* (AUS) and *Tronio* (ESP) to at least 50% of their longline sets across all research blocks, or as often as operationally possible. BVCs will be attached to a floating line between the anchor and main line (Figure 2), and will record for 15-min periods every 1 hour following 1 hour after contact with the water (i.e. to allow the BVCs to settle).

We propose to continue the use of *Star-Oddi* CTD loggers (*www.star-oddi.com/products/3/salinity-temperature-depth-logger/default.aspx*). These are the smallest loggers on the market that measure and record salinity (conductivity), temperature and depth. Recorded data is stored in the logger's internal memory with a real-time clock reference for each measurement.

b) Data collection: types and sample size or quantities of catch, effort and related biological, ecological and environmental data (e.g. sample size by location/haul)

Table 13. Summary of data collection by each participating Member. AUS – Australia; ESP – Spain; FRA – France; JPN – Japan; KOR – Republic of Korea.

Data type	Notifying Member	Number/size of samples	Collection method/device	Objective
Catch and effort	All	Every longline deployment. All fish will be identified to species where possible, including those lost at the surface.	Catch and effort data will be recorded and reported according to CCAMLR Conservation Measures in force within the proposed SSRUs (summarised in Conservation Measures 41–05 and 41–11).	1–3
Toothfish biological data: Length (cm), weight (kg), sex and gonad stage/weight	All	Target of ≥ 50 fish sex^{-1} set^{-1}. Fine-scale biological data will be collected and recorded in accordance with Conservation Measures 23–07 and 23–04. KOR will collect samples of muscle tissue (5 fish per 10cm length bin per sex per SSRU), and stomach contents (20 fish per haul), as well as plankton and zooplankton samples, for investigation of trophic relationships and ecosystem function using stable isotope analyses (Objective 4). ESP will also collect 5 *D. mawsoni* tissue samples in each SSRU for a genetic study. AUS will also collect up to 5 stomach samples per 5cm length class in SSRU 58.4.2 E which will be used by KOR under Objective 4, as well as 5 tissue samples for genetic analyses by ESP.	Biological data will be collected using electronic fish measuring board and scales (AUS) or equivalent equipment (ESP, FRA, JPN and KOR). Gonad stage will be determined by visual inspection at sea.	1, 4
Toothfish ageing	All	Five otolith pairs per 1-cm length class between 100–200 cm. Otoliths will be collected from all fish < 100 cm.	According to the AAD ageing protocol and/or CCAMLR guidelines.	1
Toothfish tagging	All	Five fish per retained tonne (green weight). In addition, KOR will continue with deployment of archival tags.	T-bar tags in accordance with the CCAMLR Tagging Protocol. One archival tag will be deployed by KOR in Division 58.4.1 during the 2016/17 season.	1
Environmental and habitat data • Depth (m) • Temperature (°C) • Salinity (PSU) • Substrate composition	AUS and KOR	CTD loggers (AUS and KOR) and BVCs (AUS and ESP) will be attached to at least 50% of longlines across all research blocks, or as often as operationally possible (i.e.≥ 1 CTD deployment per SSRU by KOR). Seafloor and fished areas will be mapped using vessel-based single-beam acoustics throughout the voyage	CTDs and BVCs attached to fishing gear.	2

• Benthic species composition • Density and structural complexity of benthos				
Bycatch	All	Standard biological data for ≥ 50 fish species^{-1} set^{-1}. Catches (kg) of VME indicator taxa will be recorded for each longline segment following protocols in Conservation Measures 22-07 and other bycatch following limits set out in 33-03.	Electronic fish measuring board and scales, or equivalent equipment (ESP, FRA, JPN and KOR). Gonad stage determined by visual inspection at sea.	3

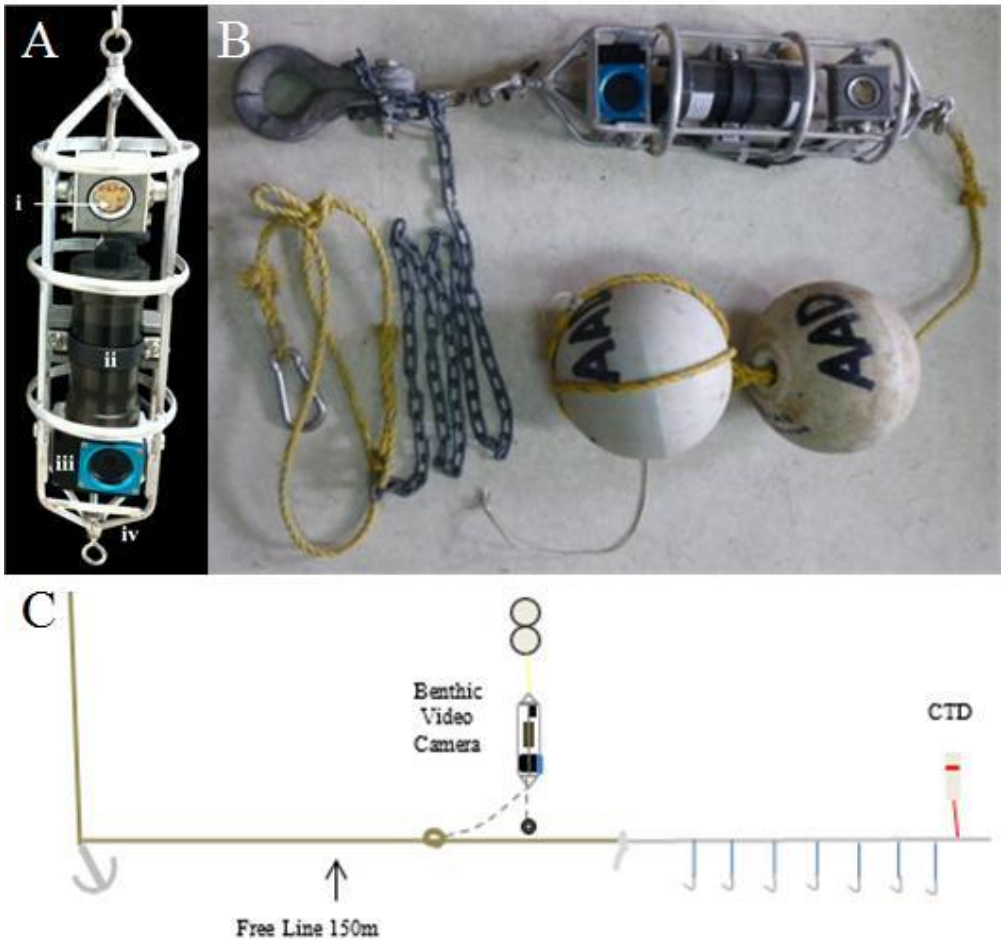

Figure 2. Benthic Video Camera system (panel A) containing light (i), battery housing (ii) and camera (iii) in crash frame (iv); its deployment setup (panel B); and attachment of BVC and CTD units on longlines (panel C). Diagram is not to scale.

(c) Method for data analysis to achieve the objectives in Section 1(a)

Objective 1: Toothfish catch rates, life-history-stage composition and size distributions will be summarized and compared between locations and depth strata. In areas where tagged fish are recovered, a detailed analysis of their movement, growth, and time at liberty will be made. Tagging and recapture data will be used in mark-recapture analyses (e.g. within CASAL or using Petersen tag-recapture models) to estimate local biomass in the research blocks. Initial stock assessments for toothfish using CASAL will utilize the following data:

- Toothfish catch (number and weight)
- Number of tagged and released fish
- Number of recaptured fish
- Catch length and age composition
- Biological parameters including estimates for growth, length-weight relationship, maturity, and natural mortality.

Objective 2: The processing of digital visual footage will be similar to those described in Welsford et al. (2014). Analysis may also be undertaken using computer programs such as *Benthic Video Annotator* (BVA) to derive benthos diversity and abundance counts from both stills and video footage. Spatially-explicit models (e.g. Generalized Linear or Generalized Additive Models) will be used to characterize the relationships between toothfish relative density and the environmental covariates listed in Table 13, and make predictions of toothfish relative densities in un-fished sites.

Vessels will provide bathymetry data in ASCII files containing latitude, longitude and depth. Where these values differ from GEBCO values, updated depth contours and polygons of fishable areas will be derived in GIS and supplied to the CCAMLR Secretariat. These bathymetric charts will also inform on the distribution of potential toothfish habitat, influencing where fish are distributed in movement or habitat-use models.

Objective 3: Bycatch species composition, catch rates and size distributions will be summarized and compared between locations and depth strata. Demographic and biological information on the species encountered will provide additional information for assessments of predominant bycatch species.

Objective 4: Trophic transfers from organic-matter sources to higher trophic levels will be traced using stable isotope ratios and fatty acid profiles. This will include investigation of trophic relationships between *D. mawsoni* and its prey, and subsequent biomarker analyses, to better understand carbon flow throughout Antarctic ecosystems.

(d) How and when will the data meet the objectives of the research? (e.g. lead to a robust estimate of stock status and precautionary catch limits). Include evidence that the proposed methods are highly likely to be successful

This research plan aims to provide a comprehensive evaluation of existing management arrangements for toothfish in Divisions 58.4.1 and 58.4.2, and updated advice on precautionary catch limits as appropriate in 2018. In addition, environmental and bathymetric data will contribute to models of toothfish habitat use following surveys in 2016/17 and 2017/18. It is also expected that data collected up to 2017/18 will allow for assessment of spatial and depth distributions and comparison of relative densities between areas for predominant bycatch

species.

The methods are highly likely to be successful based on the well-established fishing methods and sampling approaches already in place in Divisions 58.4.1 and 58.4.2, and Subareas 88.1 and 88.2. The notified vessels have extensive experience with these methods and their implementation in the Southern Ocean. Further, the research providers have a good track record of delivering science that informs management advice in CCAMLR.

BVC systems have been developed and successfully deployed in Division 58.4.1 during the 2015/16 and 2016/17 seasons. Similar devices have been deployed successfully on longlines during commercial and research fishing activities at Heard Island and McDonald Islands, and BANZARE Bank (see Welsford et al. 2014). Data from these recordings readily enabled the identification and enumeration of benthic invertebrates, and were utilized in assessments of fishing impacts on benthic habitats. More recently, WG-SAM-16/34 reported on environmental and video data collected in Division 58.4.1 by *Antarctic Discovery* (AUS) in 2015/16. This video footage indicated that the seafloor of 15 surveyed locations consisted of soft sediments or cobbles with low densities of VME indicator organisms. Motile fauna, including squids, fish and echinoderms were also recorded. Thus the video technologies needed for Objective 2 have also been demonstrated to be successful.

The employment of crew who are experienced in ice navigation and vessel handling will ensure that the vessels do not enter into areas beyond their ice classification. Fishing surveys have been planned with consideration of recent sea ice concentrations across the area using Passive Microwave Data (from Nimbus-7 Scanning Multichannel Microwave Radiometer [SMMR] and Defence Meteorological Satellite Program Special Sensor Microwave/Imager-Special Sensor Microwave Imager Sounder [DMSP SSM/I-SSMIS]) (Cavalieri et al. 1996), and detailed ice and weather forecasting from the Antarctic Climate and Ecosystem Cooperative Research Centre (based in Hobart). Based on spatiotemporal overlap between historical sea ice concentrations and fishing activities, a threshold of 40–60% sea ice cover indicated the transition from fished to non-fished conditions (Parker et al. 2014). Based on these data, research blocks in Divisions 58.4.1 and 58.4.2 typically become accessible to longline fishing during December (Figure 3). This generalisation is supported by Australia's exploratory fishing experience in Division 58.4.1, where the stratification grid in SSRU 58.4.1G was ice-free from late January to early March in 2015/16, and during late January 2016/17. Research was also undertaken in research blocks 5841_3 and 5841_4 in SSRU 58.4.1E during 2015/16 with minimal impacts from sea ice.

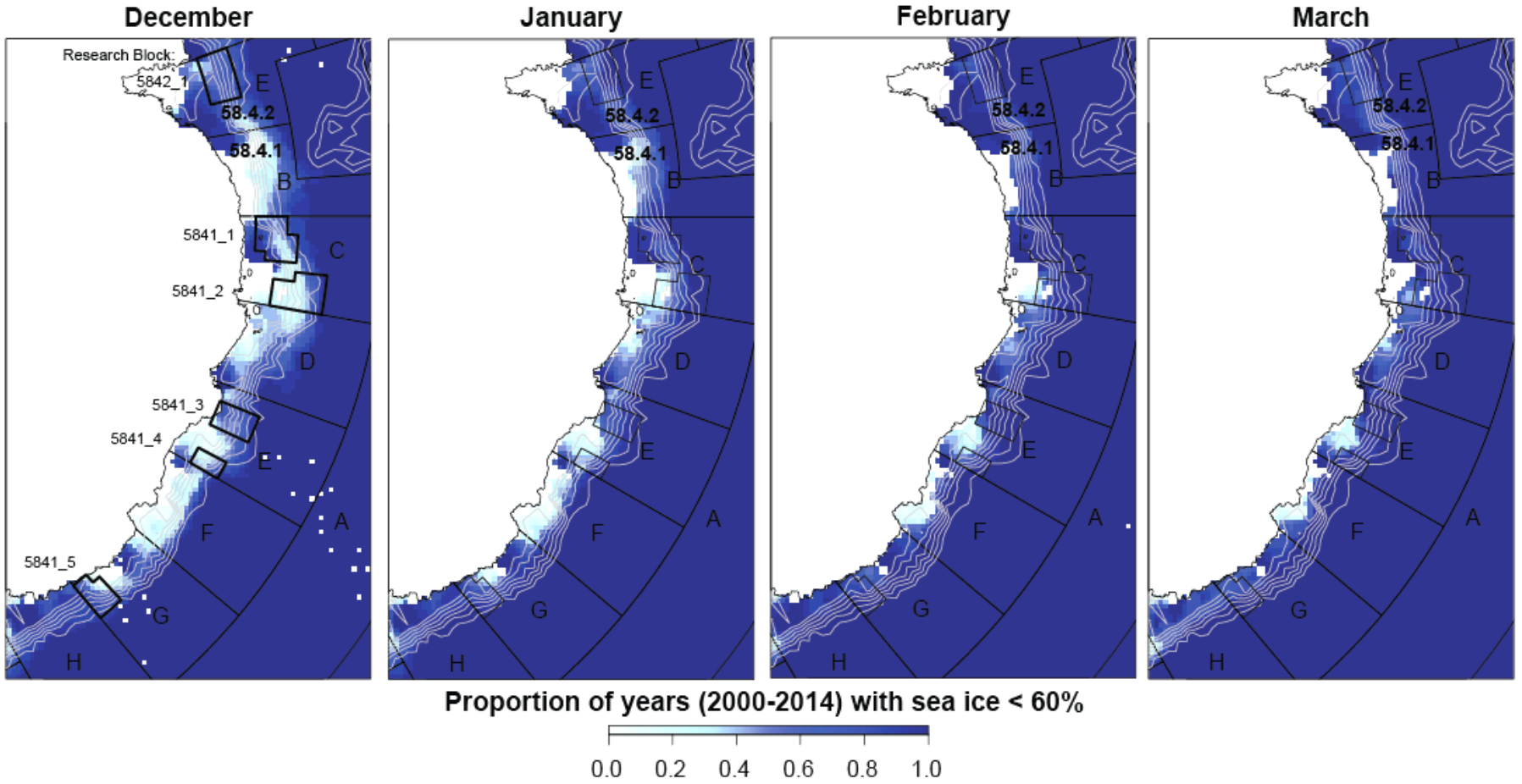

Figure 3. Proportion of years between 2000–2014 that have met criteria for longline fishability (i.e. < 60% sea ice cover; Parker et al. 2014) during December, January, February and March. Research blocks in Divisions 58.4.1 and 58.4.2 typically become accessible to longline fishing during December. Sea ice data are from Cavalieri et al. (1996). Bathymetric contours (GEBCO) are for 3000, 2500, 2000, 1500, 1000 and 550 m, heading towards the coastline.

4. Proposed catch limits

(a) Proposed catch limits and justification. (Note that the catch limits should be at a level not substantially above that necessary to obtain the information specified in the Research Plans and required to meet the objectives of the proposed research.)

We propose to adopt a similar approach to research catch allocation among participating Members to that adopted by the Commission in 2015 (SC-CAMLR-XXXIV, para. 3.245) and 2016 (SC-CAMLR-XXXV, para. 3.246; and set out in WG-FSA 15/54). Allocation of catch limits in each SSRU among notifying Members will also ensure that research effort is distributed broadly across the region in accordance with WG-SAM-16, paragraph 3.12.

We propose that notifying Members will confirm whether they intend to pursue research by SC CIRC by 1st January 2018. If any Members are not able to confirm that they will pursue research, their allocation will be evenly redistributed amongst the other notifying Members that have confirmed they will pursue research. If any Members have not commenced research fishing by 28th February 2018, their allocation will also be evenly redistributed amongst the other Members that have commenced research fishing, or in another way agreed by all of these other members.

The proposed initial catch allocations among notifying Members are outlined in Table 1 (percentages of total catch limit) and Table 14 (approximate catches based on 2016/17 catch limits). The percentage breakdowns take into account: a) the upcoming revision of catch limits scaled by new seabed area calculations for all research blocks, b) catch limits in the 2016/17 season (SC-CAMLR-XXXV, Table 7 of that document) which provide approximations of likely limits for 2017/18, c) allocations for Australia and Spain to conduct grid-stratified fishing in areas coinciding with previous depletion experiments (based on previous catches, see below), and d) equal distribution of remaining catch limits. Realised catches will also be influenced by factors such as season length and the extent of fishing by each notifying Member. Bycatch limits will be adhered to under Conservation Measures 33-01, 41-05 and 41-11.

For the 2017/18 season, an upper catch limit for Australia and Spain of 40.5t and 45t is proposed for each of the research grids in SSRU 58.4.1C and SSRU 58.4.1G, respectively (Table 14). This will allow for one 2-tonne line per grid cell for both Australia and Spain. A maximum of 2 tonnes of *D. mawsoni* were caught per line during exploratory fishing by Australia in 2015/16, however the majority of lines captured < 1 tonne, and similar catch rates have been reported in this area by Spain (Sarralde et al. 2014). Further, catches within 58.4.1G by Australia in 2015/16 totalled 35 tonnes, therefore it is likely that catch rates below 2 tonnes per line will allow for: a) more than two lines in some grid cells, or b) additional exploratory lines in other areas within the same research block.

Table 14. Example initial catch allocations in tonnes for the 2017/18 season for research plans in Divisions 58.4.1 and 58.4.2 by Research Block. The catch allocations are approximate values based on the total catch limits from 2016/17 distributed according to Table 1. Actual initial catch allocations for the 2017/18 season will be based on re-estimated total catch limits for research blocks, and should not be less than 10 tonnes per Member in each block. AUS – Australia; ESP – Spain; FRA – France; JPN - Japan; KOR – Republic of Korea.

ASD	SSRU	Research Block	Catch allocation (tonnes)						Catch limit 2017/18
			AUS	ESP	FRA	JPN	KOR	Total	
58.4.1	C	5841_1			26.5	26.5	26.5	79.5	80
		5841_2	40.5[a]	40.5[a]				81	81
	E	5841_3	30	30	60.5	73.5	38.5	232.5	233
		5841_4			13			13	13
	G	5841_5					35	35	35
		5841_6	45[a]	45[a]				90	90
58.4.2	E	5842_1	35					35	35
Total			150.5	115.5	100	100	100	566	567

[a] Allocation for research grid, and additional fishing within the research block if any catch is still available.

(b) Evaluation of the impact of the proposed catch on stock status

- ***Rationale that proposed catch limits are consistent with Article II of the Convention***
  The proposed research is not expected to have an additional impact on stock status. The catch allocations referenced in Section 4a will be based on revised catch limits which are designated to provide reasonable assurances against negative impacts on stock status, consistent with the objective of CCAMLR and a precautionary approach.

- ***Evaluation of timescales involved in determining the responses of harvested, dependent and related populations to fishing activities***
  A preliminary investigation of sources of spatio-temporal variation in toothfish and bycatch CPUE (e.g. fishing vessel and survey methods, location and timing of surveys and fishing pressure) will be presented to WG-FSA-17 and WG-FSA-18. Conditional upon CCAMLR review, survey and tag-recovery fishing in 2016/2017 and 2017/2018 will provide information on the biomass present in fished areas, and estimated long-term population responses to fishing activities.

- ***Information on estimated removals, including IUU fishing activities, where available***
  IUU fishing activities have been recorded in Divisions 58.4.1 and 58.4.2 (SC-CAMLR 2015a,b). Evidence of IUU presence or activity continues to be recorded however no recent estimates of IUU toothfish catch exist.

(c) Details of dependent and related species and the likelihood of their being affected by the proposed fishery

Based on previous catches in Divisions 58.4.1 and 58.4.2, we anticipate the most common bycatch species group to be *Macrourus spp.* (SC-CAMLR 2014a,b). Other bycatch may include:

- *Channichthyidae*
- *Muraenolepis* spp.
- *Rajiformes*
- *Antimora rostrata*
- *Notothenidae*
- *Pogonophryne* spp.

The proposed research will maintain strict compliance with conservation measures regarding bycatch (CMs 41-05, 41-11 and 33-03) and the protection of seabirds and marine mammals (CMs 41-05, 41-11 and 25-02). Previous cases of seabird and mammal mortalities in Divisions 58.4.1 and 58.4.2 have involved the southern giant petrel (*Macronectes giganteus*), sooty shearwater (*Puffinus griseus*) and leopard seal (*Hydrurga leptonyx*); however no seabird or mammal mortalities have been reported since 2005 (SC-CAMLR 2014a,b). VME-related data will be collected and notified in accordance with Conservation Measure 22-06. All registered and newly discovered vulnerable marine ecosystems (VMEs) will be avoided during fishing operations in accordance with Conservation Measure 22-07.

5. Research capability

(a) Name(s) and address of the chief scientist(s), research institute or authority responsible for planning and coordinating the research

Australia:

Dirk Welsford, Philippe Ziegler and Peter Yates
Australian Antarctic Division, Department of the Environment and Energy,
203 Channel Highway, Kingston TAS 7050, **Australia**
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France:

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Phone: +33140793755
Email: duhamel@mnhn.fr

Professor Duhamel will be assisted by scientific members of his team and, for data analysis and assessment, by Romain Sinègre (MNHN) and Aude Rélot-Stirnemann and Arthur Rigaud, (Oceanic Développement Company).

Japan:

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Email: roberto.sarralde@ca.ieo.es

(b) Number of scientists and crew to be on board the vessel

Each vessel will carry at least two scientific observers, one of whom shall be appointed in accordance with the CCAMLR Scheme of International Scientific Observation. The other will be an observer appointed by fisheries management body/s of the Members participating in this research.

(c) Is there opportunity for inviting scientists from other Members? If so, indicate a number of such scientists

There is no space available for scientists from other Members aboard the fishing vessels.

(d) Commitment that the proposed fishing vessel(s) and nominated research provider(s) have the resources and capability to fulfil all obligations of the proposed Research Plan

The nominated vessels and on-board scientific observers have the resources and capability to fulfil all obligations of the proposed research plan. For example, the vessels (listed in Section 2b) are equipped with the fishing gear and all other facilities required to conduct this research in accordance with relevant conservation measures; as well as communication systems that allow direct telephone, fax, email and internet communication between the vessel and observer coordinators and fishery scientists. The nominated vessels and fishing companies are experienced operating in CCAMLR fisheries, including in Divisions 58.4.1 and 58.4.2.

The Australian fishing vessels *Antarctic Discovery* and *Antarctic Chieftain* participated in research in Division 58.4.1 in the 2015/16 and 2016/17 seasons, respectively. Australian Longline Pty Ltd (ALPL) have a long history of high compliance and reporting performance in CCAMLR fisheries, including exploratory toothfish fisheries. In 1997, ALPL entered the

Heard Island and McDonald Islands (HIMI) fishery (Division 58.5.2) and has subsequently operated three vessels in the HIMI fishery (including the *Antarctic Chieftain* from 2009–2014). In 2007/08, *Janas* successfully conducted a random stratified longline survey to collect data on the relative abundance of toothfish and bycatch species across the entire fished area of the BANZARE Bank (Division 58.4.3b) while flagged to Australia. The information collected on this voyage revealed the importance of BANZARE Bank as a spawning ground for *D. mawsoni* (Welsford et al. 2008), since reinforced by data collected by Japan; and supported the hypothesis that the population in the area was likely to have been depleted by a combination of IUU and exploratory fishing (McKinlay et al 2008).

The fishing vessel *Le Saint-André* (France) has conducted exploratory fishing in Divisions 58.4.3a and 58.4.4b since 2012/13. The Muséum National d'Histoire Naturelle (MNHN) has previously planned and carried out three scientific surveys of the toothfish stock (POKER) around the Kerguelen Islands in Division 58.5.1. The MNHN has developed stock assessments for *D.* eleginoides in Division 58.5.1 and in the vicinity of Crozet Islands (part of Subarea 58.6) using CASAL.

The fishing vessel *Shinsei maru No. 3* (Japan) has conducted exploratory fishing in these Divisions in three seasons since 2008/09. The National Research Institute of Far Seas Fisheries of Japan is developing formal collaborations with colleagues from New Zealand to consolidate its experience in toothfish aging.

The fishing vessel *Southern Ocean* (Republic of Korea) will be replacing the *Kingstar* in the 2017/18 season. More details on this vessel change will be presented at WG-SAM-17. The National Institute of Fisheries Science (NIFS) of Republic of Korea is developing formal collaborations with colleagues from New Zealand to consolidate its experience in toothfish aging, analyses of archival tag data, and stock assessment using CASAL.

The fishing vessel *Tronio* (Spain) has conducted exploratory fishing in Divisions 58.4.1 and 58.4.2 in four seasons since 2012/13. It has fished in Division 58.4.1 from 2006, always in compliance with conservation measures. Researchers of the Spanish Institute of Oceanography (IEO) have collaborated with CCAMLR since 1986 when a Spanish Scientific Survey was conducted on the Scotia Arc and Antarctic Peninsula. Currently a program on otolith aging is underway, as well as molecular analysis for species identification.

6. Reporting for evaluation and review

(a) List of dates by which specific actions will be completed and reported to CCAMLR. If the research is a stand-alone survey, Members shall commit to providing a progress report to WG-FSA and/or WG-EMM for review and comment and a final report within 12 months of completion of the research to the Scientific Committee

A consolidated progress report was provided to WG-FSA-16 which provided a summary of data collected in previous seasons by all research participants. This report contained a preliminary evaluation of toothfish and bycatch catch compositions, data collection and tagging activities. Submissions relating to each of the research milestones will be submitted to WG-FSA-17 and WG-FSA-18 as indicated in Section 1b. A final report will be provided to WG-FSA in 2018, which will contain a comprehensive evaluation of existing management arrangements and updated advice on precautionary catch limits as appropriate.

(b) If research is multi-annual, Members shall commit to providing annual research reviews to be submitted to WG-FSA and/or WG-EMM, including review of progress towards meeting research objectives and associated proposed time lines in initial proposal, and proposals for adjustments to the research proposal if required

Following each season of data collection, a progress report will be submitted to WG-SAM and WG-FSA that addresses how the research is meeting objectives and whether any changes are required to research plans.

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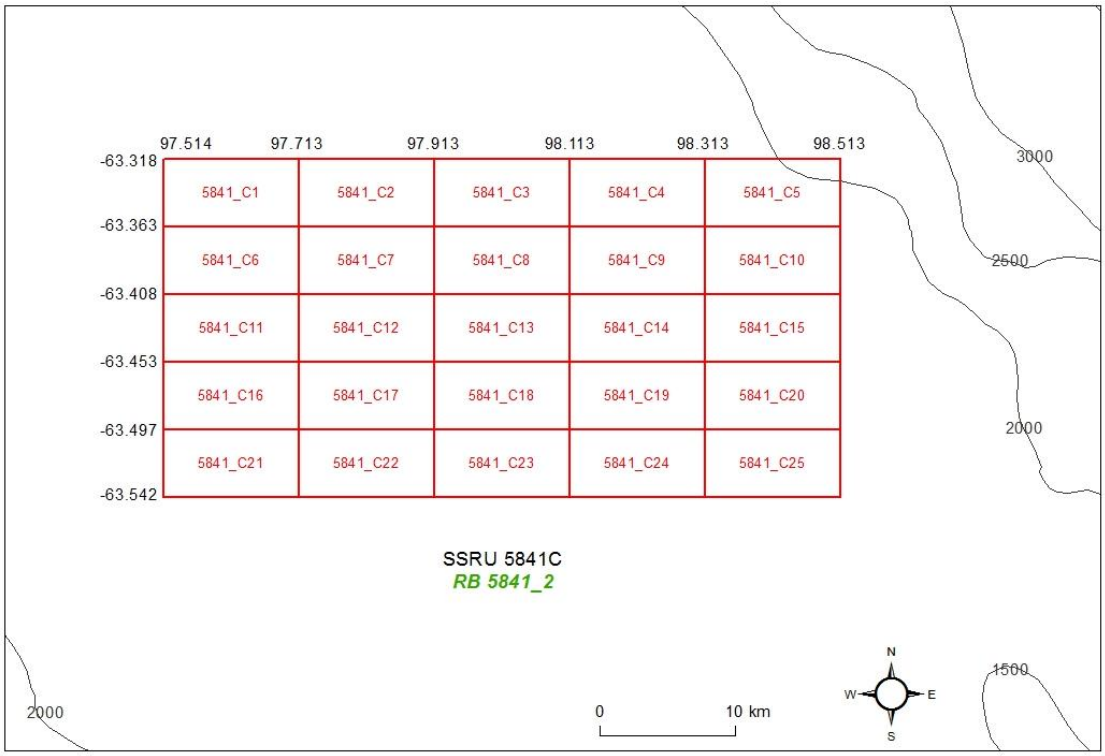
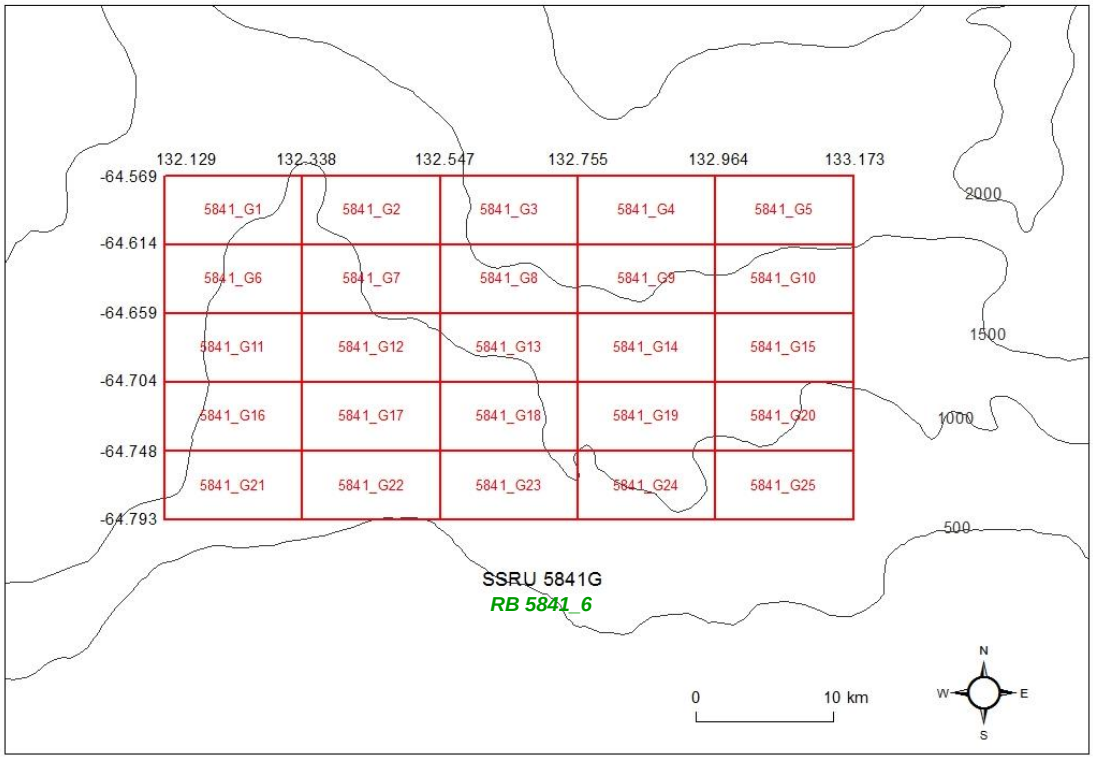


Appendix 1. Coordinates of stratification grids (comprised of twenty-five 10 x 5 km cells) within research block 5841_2 in SSRU 58.4.1C. Grey lines are GEBCO bathymetric contours (m).



Appendix 2. Coordinates of stratification grids (comprised of twenty-five 10 x 5 km cells) within research block 5841_6 in SSRU 58.4.1G. Grey lines are GEBCO bathymetric contours (m).